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We evaluated 10 years of reported hazardous cargo incident information from the U.S. Air Force and Naval Safety Centers. In this first two papers describing the hazardous cargo problems reported by the two services, we describe types of aircraft and types of hazardous cargo involved in incidents not causing aircraft mishaps. Normally, hazardous cargo must be manifested as such and no passengers are allowed on such flights. Unauthorized hazardous cargo was found on military aircraft carrying passengers. The most common problem was fuel spills or fumes. The most frequent cause of a hazardous cargo incident was improper manifest of same. Improvements are recommended fro the incompatible or inconsistent hazardous cargo incident reporting systems, in order to improve prevention of hazardous cargo incidents.

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TECHNICAL NOTE

Hazardous Materials Incidents in Military Aircraft

V. M. VOGE, M.D., M.P.H., and G. TOLAN, M.D.

VOGE VM, TOLAN G. *Hazardous materials incidents in military aircraft*. Aviat. Space Environ. Med. 1993; 64:658–61.

We evaluated 10 years of reported hazardous cargo incident information from the U.S. Air Force and Naval Safety Centers. In this first of two papers describing the hazardous cargo problems reported by the two services, we describe types of aircraft and types of hazardous cargo involved in incidents not causing aircraft mishaps. Normally, hazardous cargo must be manifested as such and no passengers are allowed on such flights. Unauthorized hazardous cargo was found on military aircraft carrying passengers. The most common problem was fuel spills or fumes. The most frequent cause of a hazardous cargo incident was improper manifest of same. Improvements are recommended for the incompatible or inconsistent hazardous cargo incident reporting systems, in order to improve prevention of hazardous cargo incidents.

THE CORRECTLY manifested transportation of properly packaged hazardous cargo is rarely a problem on U.S. military aircraft. The transportation of hazardous cargo on military aircraft is strictly regulated by OPNAVINST 4660.3, Chap. 5 in the U.S. Navy, and AFR 71-4 in the U.S. Air Force. The Army depends on the Air Force for the transportation of most of its cargo. Each service's regulation essentially stipulates that passengers shall not be embarked on aircraft when hazardous cargo is being carried.

Tupper described some of the routine hazards found on airevac aircraft (1), but no survey of all types of aircraft has been published. This is the first of two complementary papers describing reported military hazardous cargo incident information. This paper will deal with type of aircraft involved, type of hazard reported, and aircrew response to the hazard. The second paper in this series will describe physiological responses of aircrew or passengers to the various hazardous chemicals.

METHODS

We requested data on all aircraft incidents involving hazardous cargo on military aircraft from both the Air Force and the Naval Safety Centers for the decade beginning 1 January 1980. The Army Safety Center did not have a database with this information. Aircraft mishap (actual "accidents") information was not included in the request because of the frequent controversy or sensitivity surrounding the exact cause or contributing cause of many mishaps. All individual aircraft incident reports were examined and information extracted as to: type of aircraft involved; whether the hazardous incident occurred in flight or on the ground; the precipitating or causal factor(s) of the incident; the type of hazard on board the aircraft; the estimated quantity of a spill (when reported); the aircrew response to a hazard; whether passengers were on board; the physiological responses of aircrew or passengers to the hazard; and how the hazardous condition was resolved. Cargo overload is included as a type of hazardous cargo. Such overloading can be just as hazardous to aircrew and passengers as any toxic chemical.

RESULTS

The Air Force reported a total of 239 hazardous cargo incidents and the Navy reported 88 incidents over the decade investigated. The incident reports occasionally lacked information as to whether a flight was aborted; whether the flight was manifested to carry hazardous materials; whether the incident took place in flight or on the ground; exactly what the hazard was; and what actions were taken by the crew to resolve the problem. Consequently, some of our results reveal descriptive information only. Actual numbers are given where practical and available. Almost all the reported hazardous cargo incidents were on flights where hazardous cargo was apparently not manifested and passengers could well have been on the flights.

Some of the actual abbreviated incident reports merit inclusion for illustrative purposes:

From Clinical Sciences, Armstrong Laboratory, Brooks AFB, TX.
This manuscript was received for review in September 1992. It was revised and accepted for publication in December 1992.
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Example 1

". . . aircraft on routine logistic support mission. Weight of cargo estimated at 20,679 lbs. (9380 kg) . . . all weights are estimated. . . . On takeoff slide, aircraft accelerated to 45 kt and stagnated. Two more takeoffs were attempted with stagnation between 40 and 50 kt. Attributing stagnation to poor skyway conditions, decision made to offload two pallets . . . 5,259 lbs. (2385 kg), leaving a total cargo weight on aircraft of 15,420 lbs. (6995 kg). Takeoff was successful . . . cargo was offloaded and reweighed. Actual weight of pallets totaled 23,170 lbs. (10,510 kg) putting CG very near aircraft limits." Note: (7,750 lbs. (3515 kg) excess after takeoff and at least 13,000 lbs. (5897 kg) before offload!!)

Example 2

". . . crew chief was gathering his personal belongings when he noticed a transparent plastic shopping bag under a passenger seat. . . . a 16 fl. oz. (1 L) can of "Wizard" charcoal lighter fluid. The can had swollen considerably in size due to pressure differential. . . . Fluid was brought on board by 16-year-old dependent, who had been processed through passenger screening at the air terminal."

Example 3

". . . . A hydraulic servicing bowser was found leaking from hose. . . . oil was found leaking onto pallet under a locked cruise box; 2 nose tires found inflated to 125 psi and not tagged with deflation tags; approx. one case of beer was located in cruise box . . . an oil bowser was found leaking oil inside a cruise box; 4 fuel sample bottles and container were found in another cruise box with approx. 1.5 quarts (1.4 L) of fuel remaining. . . , and 2 one-quart (1-L) plastic bottles labeled as some type of lubricating oil. Two (other) cruise boxes were locked. . . . The potential for inflight disaster in this case was extreme. Departure point coordinator did not do his job."

Example 4

"During the third leg of an overwater flight, prior to landing . . . for customs, a scheduled passenger produced a 9-mm semi-automatic short stub assault rifle with a 32-round clip that was full. He was not authorized to have a weapon."

Example 5

"Upon descent at FL 250, liquid was noted leaking from a wooden box. When the liquid came into contact with the aluminum floor, it began to bubble and actively corrode, turning the floor black. Descent angle allowed liquid to run forward toward passengers and seep through flooring. . . . Uneventful landing was made. Crash crew refused to respond to wash down and neutralize spill. FMS personnel responded."

About 95% of reported Air Force hazardous cargo incidents occurred inflight, resulting in emergency landings in 49% of cases. Only 60% of the Navy's reported incidents occurred in flight, resulting in 40% of the flights being aborted (Table I). When pilot action was reported after discovering problems with hazardous cargo (fumes, spills), the command pilot, as per regulation, usually ordered all crew and passengers to don oxygen masks while normal smoke or fume elimination procedures were carried out. These routines frequently included aircraft depressurization and descent in altitude. (The aircraft is depressurized to enable easy ventilization of fumes to the outside of the aircraft and to facilitate air exchange. Aircrew and passengers don oxygen masks, even in the presence of flammable liquids or fumes, to avoid aircrew or passenger incapacitation from fume inhalation. In such instances, there is little danger of explosion since the amount of oxygen vented to the ambient air is extremely small.)

TABLE I. GENERAL INFORMATION: HAZARDOUS MATERIALS INCIDENTS, USAF VS. NAVY, 1980–89.

	Air Force	Navy
Number of incidents	239	88
Number of incidents discovered in-flight	226 (95%)	53 (60%)
Number of in-flight incidents resulting in flight abort	111 (49%)	21 (40%)
Number of incidents discovered on ground	13 (05%)	34 (39%)
Number of incidents not reporting in-flight vs. ground	0 (00%)	1 (01%)

Breaking out the information by aircraft type, most of the Air Force's incidents were reported in the C-141 aircraft, followed by the C-130 and the C-5 (Table II). Other aircraft involved, but with less than five hazardous cargo incidents each during the study period, were the KC-10, C-135, C-9, and others (helicopters, contract aircraft, etc.) The U.S. Navy reported most of its hazardous cargo incidents in the C-9 aircraft, followed by the C-130. Only one incident was reported in the P-3 aircraft. In contrast to the Air Force's statistics, 44% of the Navy's C-9 incidents were discovered while the aircraft were still on the ground and before takeoff. Consequently, only 29% of the C-9 hazardous cargo incidents resulted in an emergency landing. The numbers for the Navy's C-130 aircraft (most of which belong to the Marine Corps) also reflect this difference.

The most frequent hazardous cargo incidents reported were from fuel spills (Table III). Fuel spills accounted for 75% of problems in the Air Force and 35% in the Navy. The fuel was of all types, including JP-4, -5, -7, -8, MOGAS, diesel, etc. The Navy incident reports did not estimate amount of fuel spilled. The Air Force's average amount of fuel spillage, when reported, was 2.5 gal. (9.5 L), with a range from 0.5 pint (0.24 L) to 20 gal. (76 L). Frequently, there were several types of hazardous cargo found on board, simultaneously exposing the aircrew to several hazards. The next most frequent hazardous cargo problem for the Air Force was corrosives, explosives, caustics and acids, with solvents coming in third.

The picture in the Navy is somewhat different. Misweighed or unweighed pallets posed the second greatest hazard for Naval aircraft. Another problem the Navy alone seemed to experience was overinflated tires as cargo. Regulations state that all tires transported by air must have a pressure of no more than 25 psi.

Tables IV and V outline the specific hazardous cargo situations reported by the Air Force and Navy. Breaking this information out by aircraft type did not reveal specific problems for any aircraft type. The reasons most frequently given for hazardous cargo being on board were: cargo manifests were not correct; fuel tanks were not drained; containers were not certified for air travel; engines were not purged and drained; containers were not inspected carefully before being loaded on board the aircraft; containers were overturned during loading; containers broke; personnel loading the pallets were not fully qualified or did not perform their tasks properly.

The Air Force incident reports identified various methods aircrew used to attempt to clean up the spills. These methods included the following: absorbent mate-

TABLE II. INCIDENTS REPORTED, USAF VS. NAVY, 1980–89, BY AIRCRAFT TYPE.

Air Force	Aircraft Type					
	C-141	C-5	C-130	KC-10	KC-135	other
Number of incidents (n = 239)	144	32	53	4	2	4
In-flight incidents	138 (96%)	31 (97%)	47 (89%)	4 (100%)	2 (100%)	3 (100%)
In-flight incidents aborted	66 (48%)	12 (39%)	30 (64%)	1 (25%)	1 (50%)	1 (33%)
Ground incidents	6 (04%)	1 (03%)	6 (11%)	0 (00%)	0 (00%)	0 (00%)

Navy	Aircraft Type		
	C-9	C-130	P-3
Number of incidents (n = 88)	62	25	1
In-flight incidents	34 (55%)	19 (76%)	1 (100%)
In-flight incidents aborted	10 (29%)	10 (53%)	1 (100%)
Ground incidents	27 (44%)	6 (24%)	0 (00%)
Unknown ground vs. air	1 (02%)	0 (00%)	0 (00%)

TABLE III. MOST FREQUENT HAZARDOUS CARGO PROBLEMS.

	Air Force	Navy
Fuel (all types)	162	30
Corrosives/explosives/caustics/acids	29	10
Solvents	13	10
Hydraulic fluid	12	11
Overpressurized tires	0	7*
Overweight (displaced CG)	0	17**

* Up to 150 pounds reported; should be no more than 25 pounds per square inch (psi).
** Up to 7,750 pounds (3515 kg).

TABLE IV. AIR FORCE HAZARDOUS CARGO INCIDENTS: FUMES AND LEAKS (ALL AIRCRAFT).*

- Fuel:
  - JP-4 (37)
  - JP-5 (7)
  - JP-7 (1)
  - JP-8 (4)
  - Diesel (13)
  - MOGAS** (14)
  - Unknown (85)
- Average spill: 2.5 gal. (range: 1/16–20 gal.) (0.24–76 L)
- Acids, all types (18)
- Acetylene
- Aircraft cleaning compound
- Bromochloromethane
- Calcium hypochlorate, hydrated
- "Caustic leak", NaOH (2)
- Corrosives and explosives
- Creosote
- Cyanide solution/alkaline liquid
- Deicing fluid/oil leak (2)
- Epoxy primer
- Fire extinguisher chemicals
- Hydraulic fluid (12)
- Liquid cement
- Lithium battery (2)
- LOX (liquid oxygen)
- Methyl(ethyl)ketone (3)
- Non-slip deck coating
- Oil (2)
- Oxyhydrogen flame generator liquid (alkaline)
- Paint drier
- Paint
- Paint thinner/solvent (2)
- Pesticide (triazine)
- Potassium hydroxide
- Propane (2)
- Purging fluid (2)
- Rocket motor fuel/torpedo fuel (2)
- Toluene
- Trichloroethane (2)
- Unknown fluid/fumes (11)

* Number of instances appear in parentheses.
** Highly flammable fuel additive.

TABLE V. NAVY HAZARDOUS CARGO INCIDENTS (ALL AIRCRAFT).*

Fumes and leaks
- Gas/fuel (30)
- Cleaning fluid/solvent (6)
- Coolanol (2)
- Duplicating machine fumes
- Ether
- Heat transfer fluid
- Hydraulic fluid (11)
- Liquid/contact cement/glue (4)
- Lithium batteries
- Oil (9)
- Paint primer
- Paint remover
- Toluene
- Trichloroethane
- Trichlorotrifluoroethane
- Turbine engine lubricant
- Varnish/paint/laquer (2)
- Unknown material (3)

Other
- "Break free" (petrol. distillate)
- Charcoal lighter fluid
- CO_2 cartridges (4)
- Flammable liquid nitrogen oxide with helium
- Fuel tank sealing compound (FP 44°F)
- Inaccurate cargo weight (17) ave. 2242 lbs. or 1017 kg (1000–7750 lbs. or 454–3515 kg)
- High tire pressure (7) ave. 109 psi (75–150 psi)
- Liquid chlorine poison
- MK-13 flares/smoke grenades (3)
- Spray paint
- Titanium tetrachloride
- Weapon

* Number of instances appear in parentheses.
Note: On some aircraft, there was more than one incident.

rial, blankets, buckets, marline, masking tape, paper towels, plastic/plastic bags, rags, speedy dry, and vermiculite. Air Force transports carry a kit (which includes vermiculite) for cleaning up spills. These kits usually did not fully alleviate the situation. No information on how spills were handled was found on Naval hazardous cargo incident reports.

DISCUSSION

The Air Force reported nearly three times as many hazardous cargo incidents as did the Navy. This could be due to more sorties flown, more cargo hauled, better reporting, or proportionally more incidents. The incidence data were not adjusted for the number of cargo sorties flown or the total weight of the cargo carried. The issue is not which service or aircraft is better. The purpose of this paper is to focus attention on where the problems exist. Underreporting is likely because of additional paperwork, the lack of incentive because of a failure to correct previously reported incidents, and fear of reprisal for accepting unsafe cargo aboard the aircraft.

The reporting formats for the two services differ somewhat. Some important information not required by

current guidelines follows: whether the cargo was actually manifested as hazardous or not; when, why and how a decision was made to abort or not to abort the flight; exactly how the hazardous problem was handled and what type of corrective action was taken to prevent a recurrence. The only consistently required information was: aircraft type, hazard type (although not always clearly defined), inflight vs. on ground (pre-takeoff or post-landing), and a short narrative written according to the reporting aircrew's discretion. It would seem prudent for the military services to devise a standard reporting form that would define the hazardous cargo problems more clearly in order to facilitate their prevention.

Concerning the Navy's hazardous cargo problems, 39% were found before takeoff. None of the Navy's reported hazardous cargo problems were found after landing. The Air Force hazardous cargo incidents reported while on the ground were equally distributed before and after flight. This may be due to the missions of the two services. Cargo and passenger transportation is more the Air Force Military Airlift Command's (MAC's) primary mission. The Naval Reserve possesses most of the Navy's C-9 aircraft and uses them for logistic purposes to transport goods and people, usually from bases the MAC system does not frequently visit. Notably, the second most frequent problem in the Navy seems to be misweighed or unweighed cargo pallets. Most Naval air terminals are not officially in the business of cargo transport. Often, there are no scales for weighing the cargo. In aircraft that were able to get airborne with excessive weight, the misweighed cargo accounted for up to 7,750 lbs (3515 kg) of excess manifested weight. The excess manifested weight jeopardizes the safety of flight, especially if it significantly changes the aircraft's center of gravity (CG). The Navy or Marine Corps aircrew frequently experience problems with misweighed and mislabeled pallets. Consequently, the C-9, and probably the C-130, loadmasters have learned to be very wary. Usually, anything at all questionable about a piece of cargo is thoroughly investigated before takeoff.

The Air Force seemed to have most of its hazardous cargo problems with fuel spills of all sorts. Such fuel spillage was also a major problem in the Navy, although we have no quantity estimates.

Another problem the Navy alone seems to experience is overinflated tires as cargo. If the required pressure (25 psi) is exceeded, there is danger the tire may explode, acting as a bomb, when the aircraft is at altitude, even if cabin pressure is not lost.

Frequently cargo manifests are not correct; fuel tanks are not drained; containers are not certified for air travel; engines are not purged and/or drained; cargo is not inspected carefully before being loaded on board the aircraft; containers are overturned during loading or flight; containers break; personnel loading the pallets are not fully qualified or do not follow published procedures. The Navy has some unique problems since much of what is shipped on Naval aircraft is shipped in "cruise boxes." Cruise boxes are usually large metal boxes used to hold a variety of things the deploying squadrons must carry from place to place. The personnel packing the cruise boxes many times are not aware of which substances are airworthy and which are not. The transporting aircrew finds the pallets loaded and ready to go. Schedules frequently do not permit the loadmaster to carefully inspect the cargo, unless something makes him or her suspicious. Frequently, the first suspicion the loadmasters or aircrew have that something is not as it should be is when someone notices fumes or a spill on the deck.

CONCLUSIONS AND RECOMMENDATIONS

All military aviation medical practioners should be aware of the possible hazards aboard aircraft passing through their bases. Although excessive weight is not a medical problem, toxic fumes, caustic liquids, and flammable substances can lead to human incapacitation.

The reporting of hazardous cargo incidents should be standardized across the services to include important prevention and action information. Incentives are needed to prevent the loading of hazardous cargo. Such incentives could follow guidelines already established by the services' beneficial suggestion programs; e.g., monetary or other rewards for those discovering and reporting hazardous cargo problems before aircraft takeoff. Also, aggressive Command attention to reported problems could greatly help to overcome aircrew complacency in reporting such problems. Lessons learned should be shared amongst loadmasters, safety officers and physiologic training officers. Hazardous cargo incident and mishap potentials should be addressed in premishap plans.

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